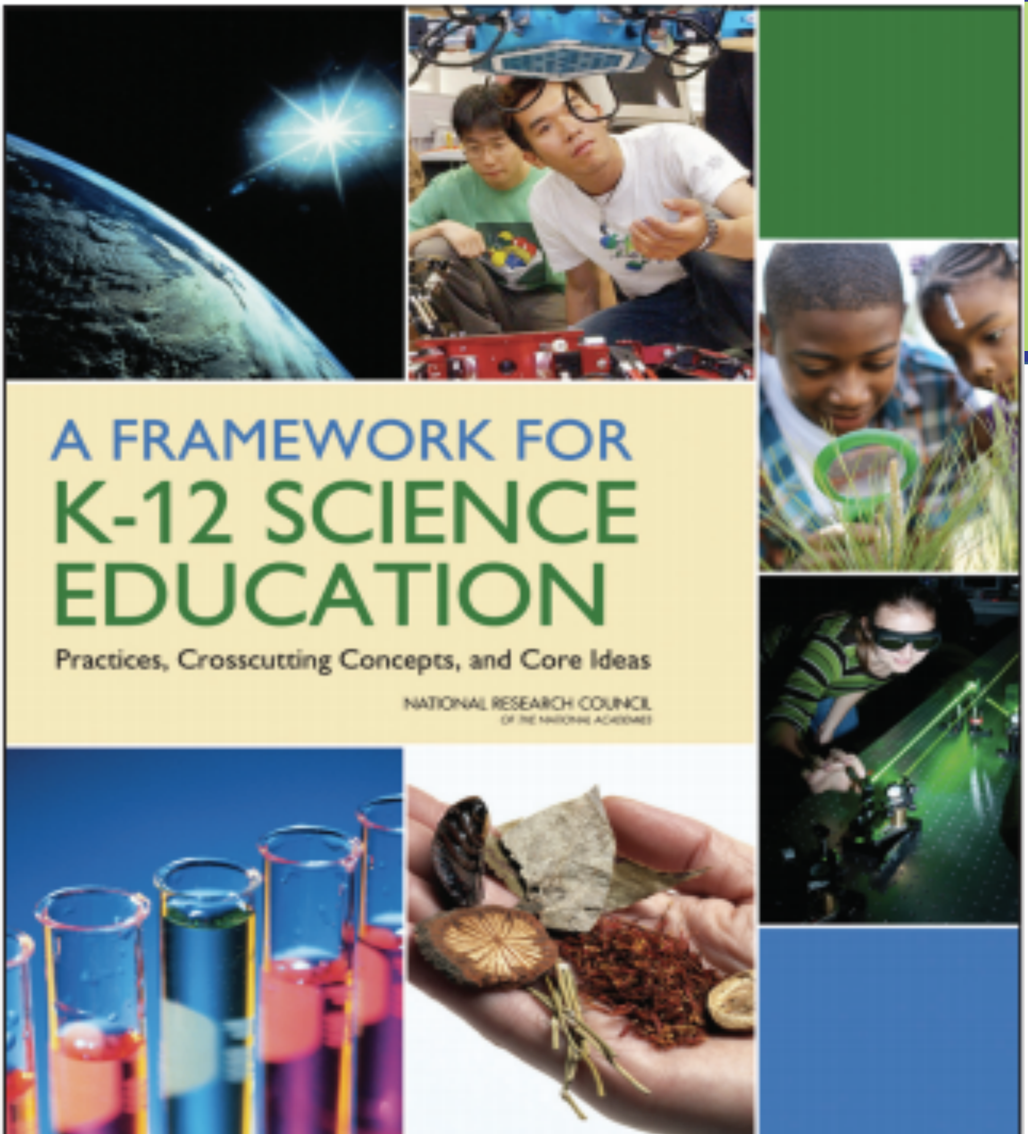

NEXT GENERATION
SCIENCE
STANDARDS

Next Generation Science Standards for Today's Students and Tomorrow's Workforce

Contact Information

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www.resa.net/science - Science Explosion songs, GLOBE songs, ICCARS, K12Science Podcasts, Today's Documents

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Lead Partners

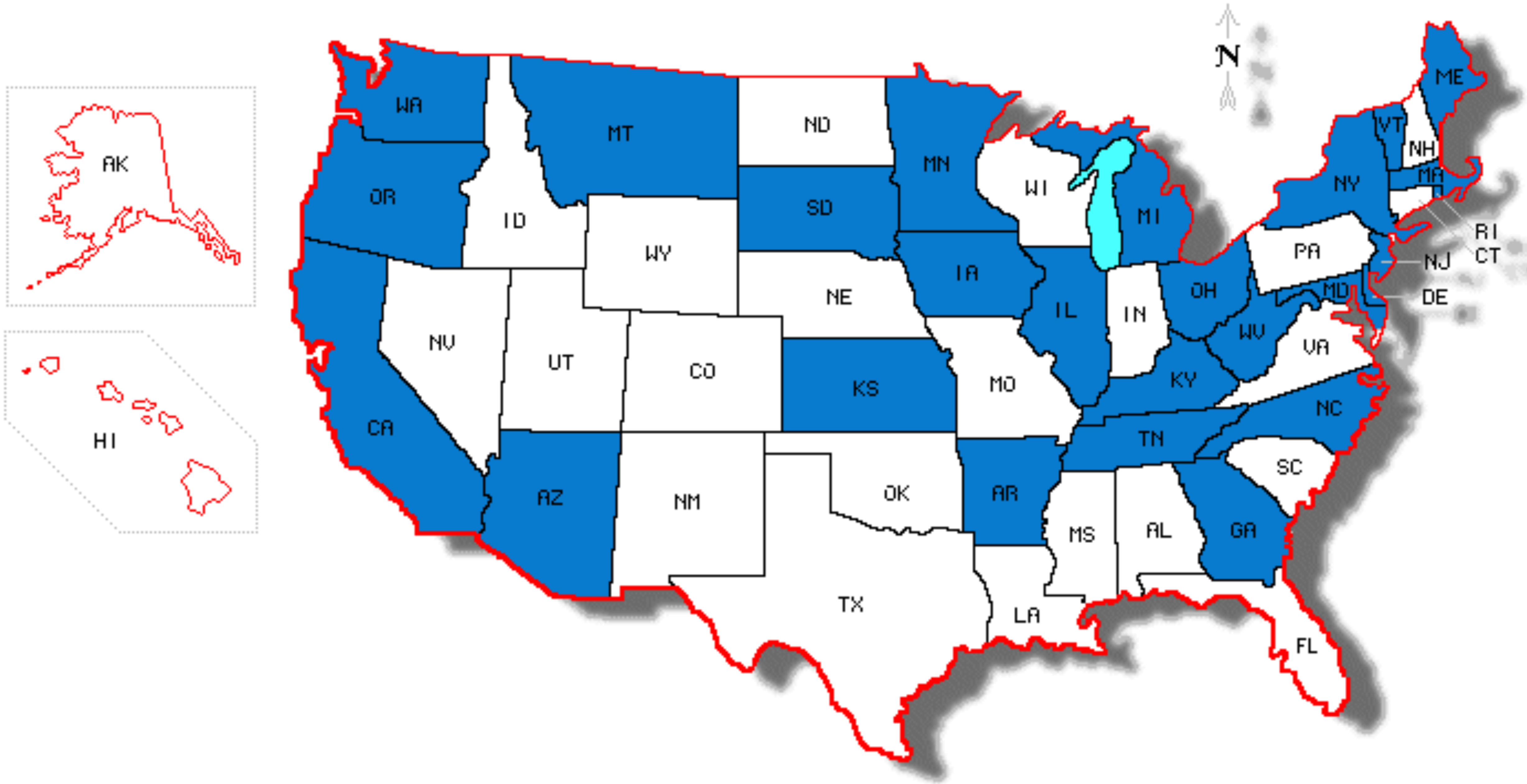
NRC

NSTA
National Science Teachers Association

Council of State Science Supervisors

Achieve

NGSS Lead States



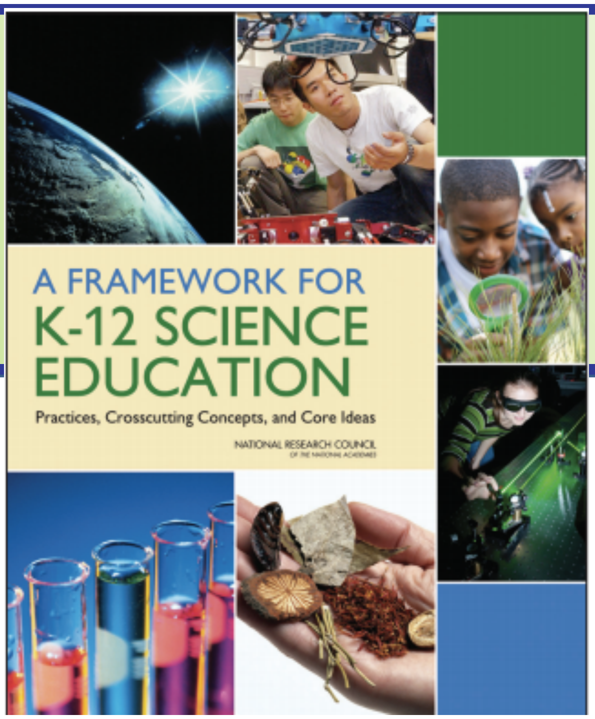
What is your level of familiarity with the *Next Generation Science Standards*?

A. Today is my first exposure to it.
B. I’ve heard it mentioned, but don’t know many details.
C. I’ve attended one or more presentations about it and/or read about it in detail.
D. I participated in a lead state review or critical stakeholder review of one of the earlier drafts.

What is your level of familiarity with the *K-12 Framework for Science Education*?

A. Today is my first exposure to it.
B. I’ve heard it mentioned, but don’t know many details.
C. I’ve attended one or more presentations about it and/or read about it in detail.
D. I participated in a lead state review or critical stakeholder review of one of the earlier drafts.

A New Vision of Science Learning that Leads to a New Vision of Teaching

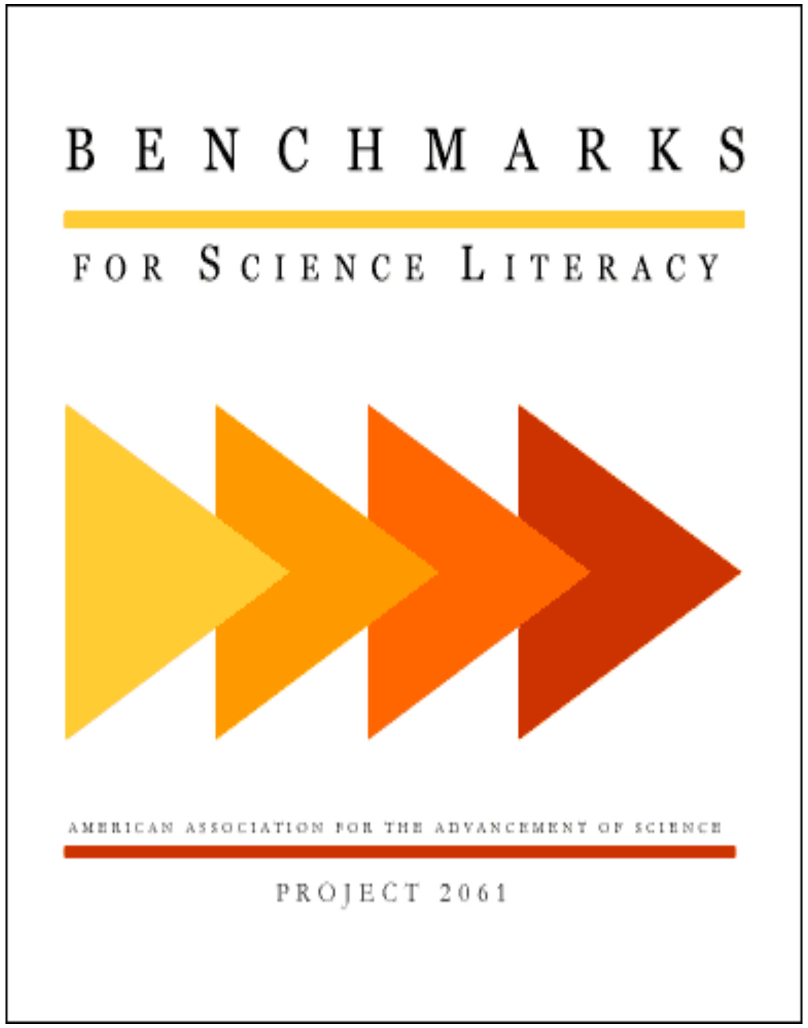


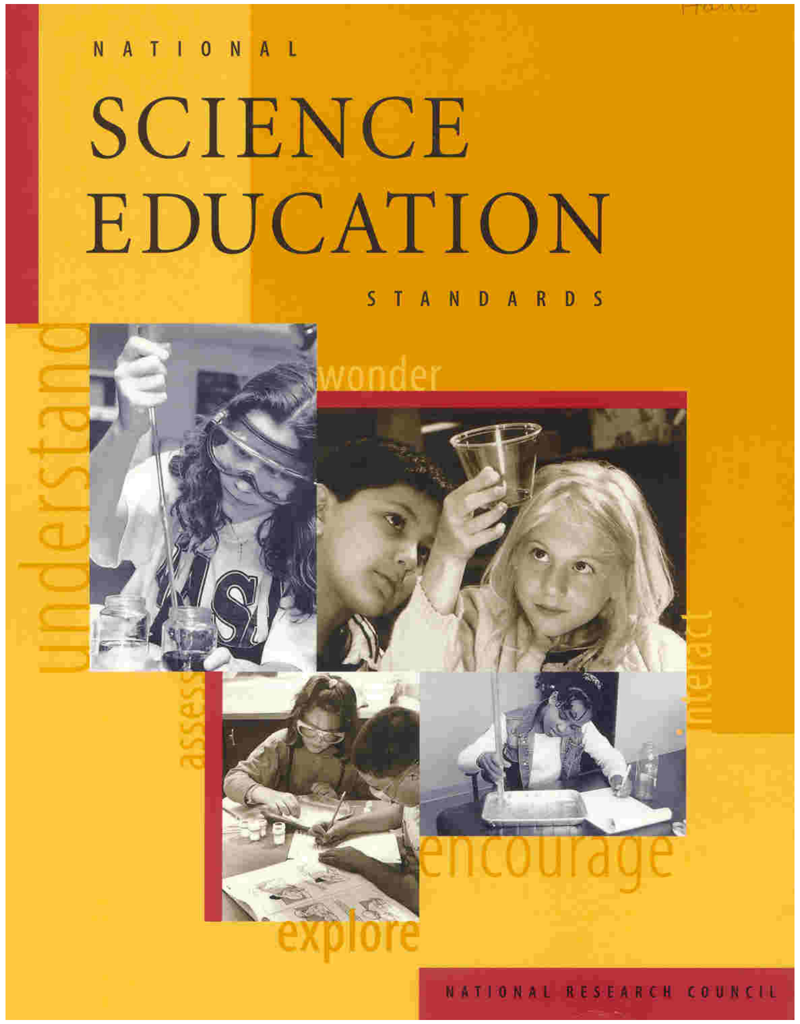
The framework is designed to help realize a vision for education in the sciences and engineering in which students, over multiple years of school, actively engage in science and engineering practices and apply crosscutting concepts to deepen their understanding of the core ideas in these fields.

A Framework for K-12 Science Education p. 1-2

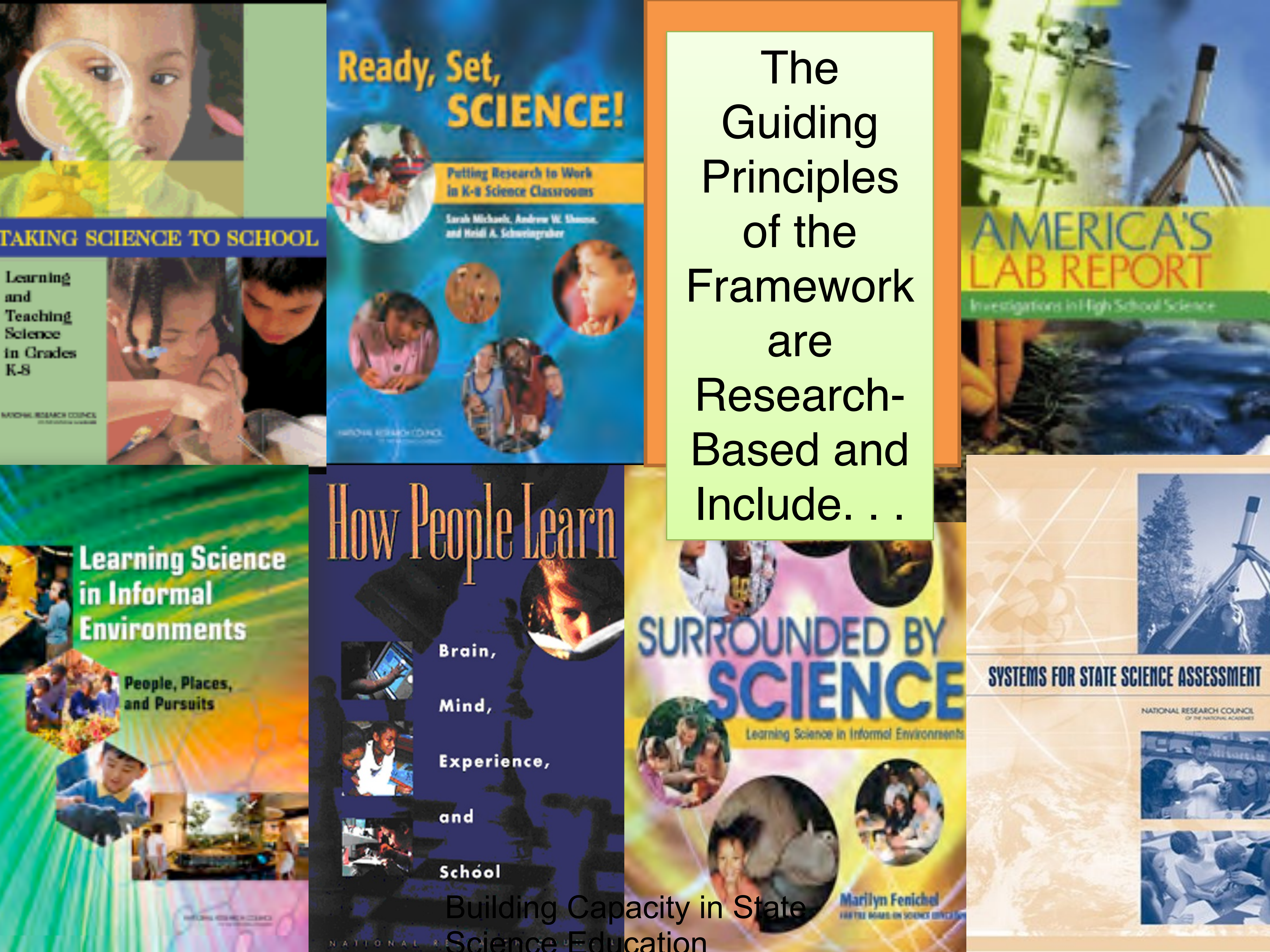
Vision for Science Education

Builds on Existing National Science Education Efforts





The Guiding Principles of the Framework are Research-Based and Include. . .

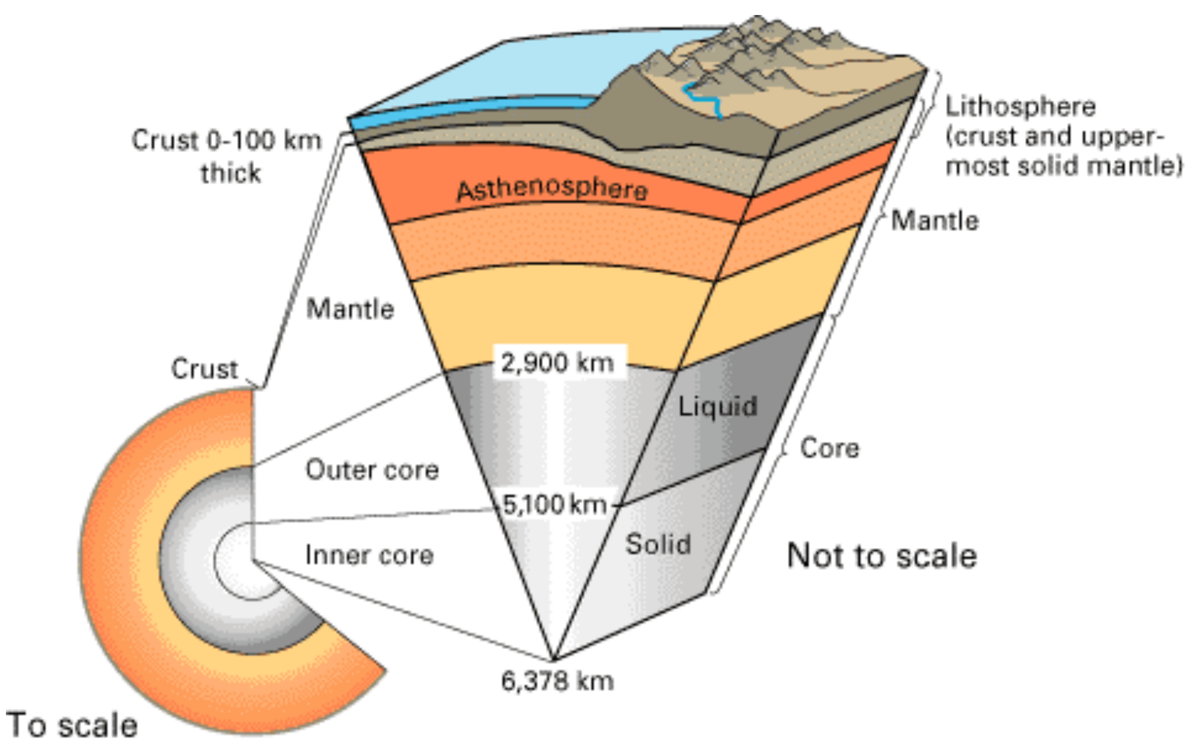


Children are Born Investigators

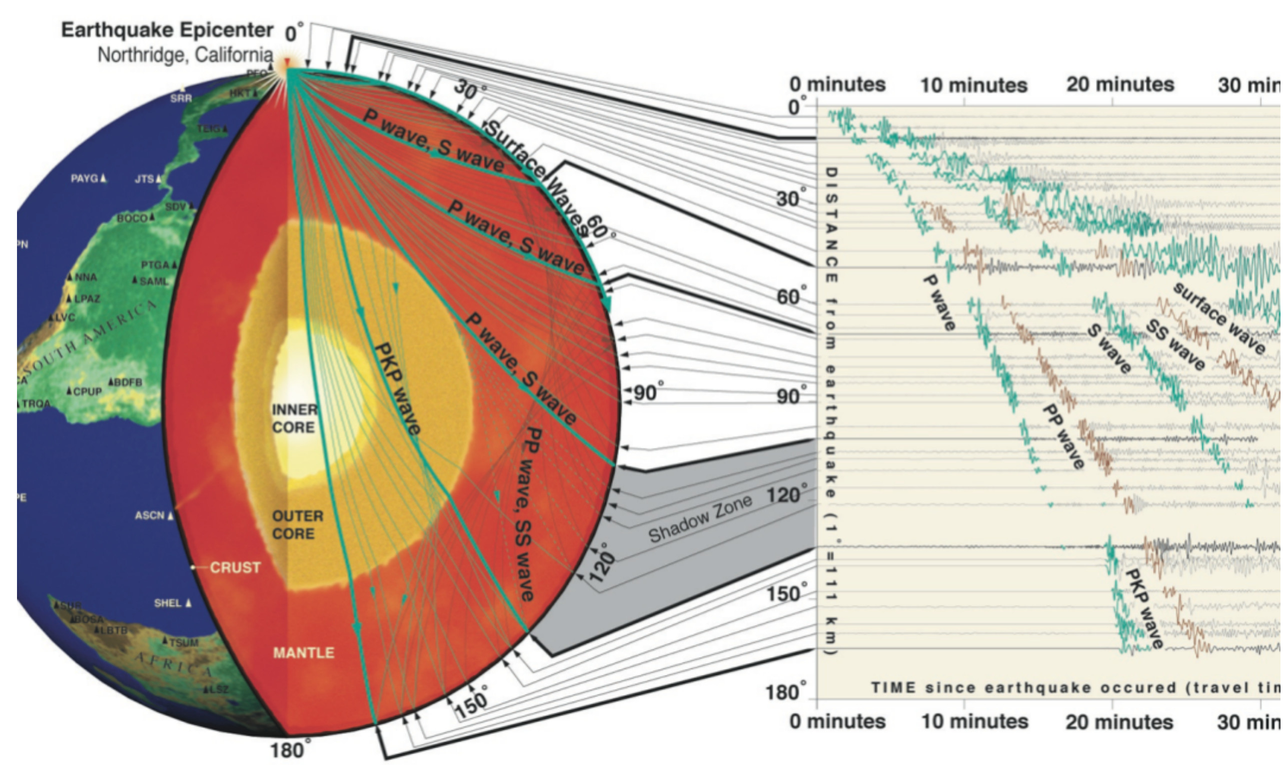
Next Generation of Science Standards (NGSS)

Compare two presentations of science content.

The earth is divided into concentric spheres. There is an iron-nickel inner core surrounded by a liquid outer core. The mantle surrounds the core and is able to flow like a plastic. The outer most layer is a rigid crust.



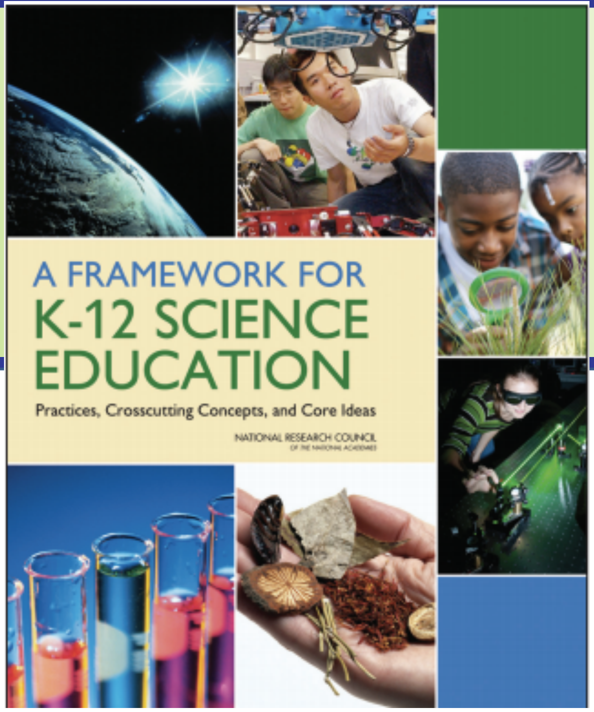
The currently accepted model of earth's interior is based largely on the analysis of seismic waves which indicates that earth is comprised of concentric spheres.



The framework is built on the notion of learning as a developmental progression. It is designed to help children continually build on and revise their knowledge and abilities, starting from their curiosity about what they see around them and their initial conceptions about how the world works.

Framework 1-3

Organization of Framework



Dimensions of the Framework

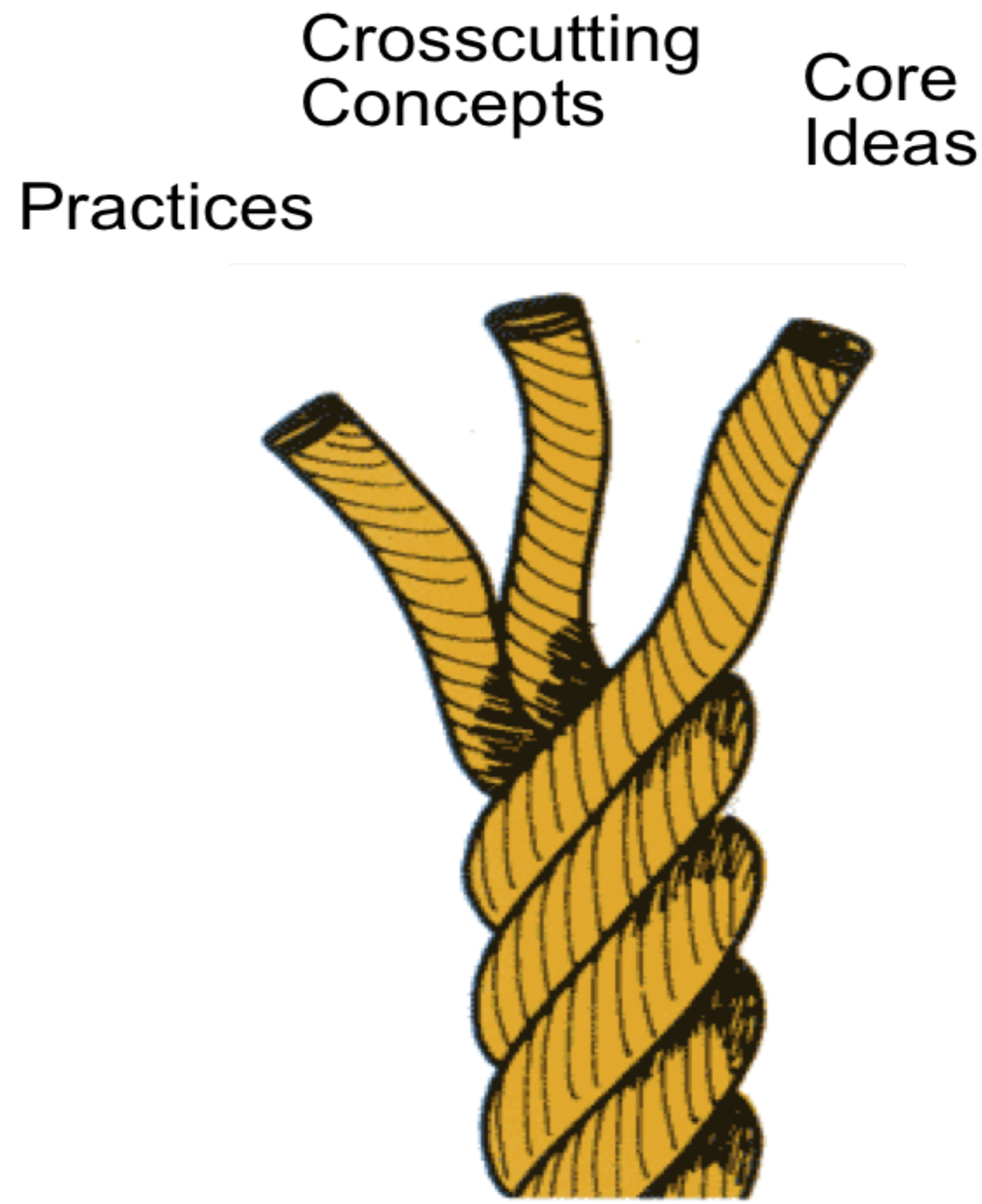
- Scientific and Engineering Practices
- Crosscutting Concepts
- Disciplinary Core Ideas

Realizing the Vision

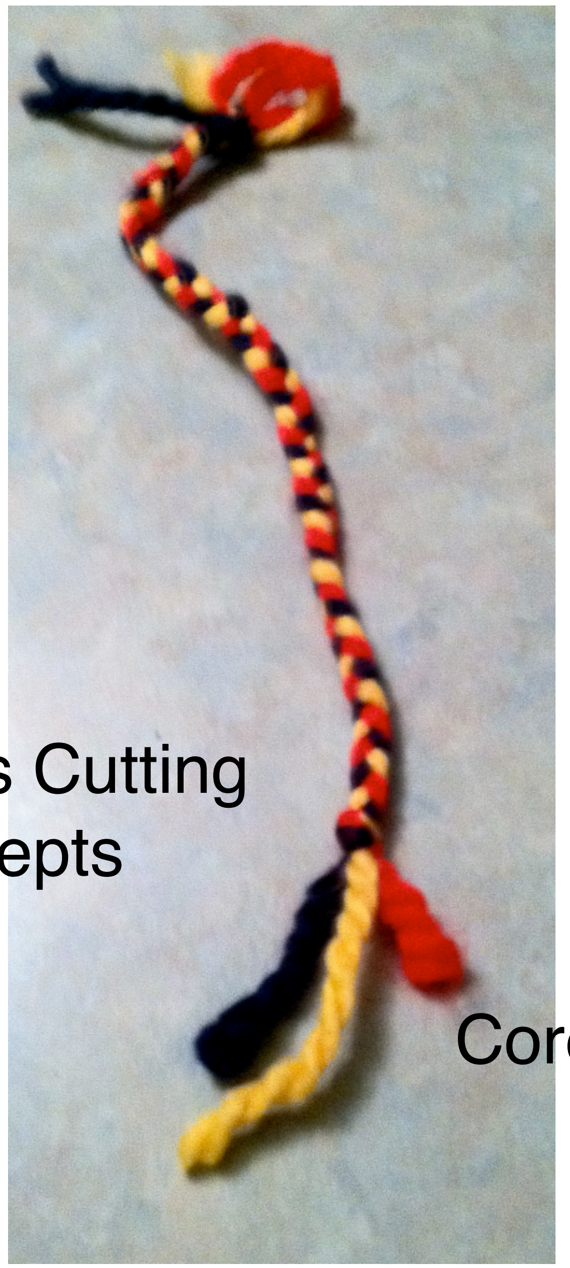
- Integrating the Three Dimensions
- Implementation
- Equity and Diversity
- Guidance for Standards Development
- Looking Toward the Future: Research to Inform K-12 Science Education Standards

NGSS Architecture

Integration of practices, crosscutting concepts, and core ideas.



What is the Value of Weaving the Three Dimensions of the Framework Together?



Cross Cutting Concepts

Core Ideas

Practices

- **Strengthening** Scientific Thinking
- **Lengthening** Scientific Thinking
- Develop **Flexible** Scientific Thinking
- **Making Connections** within Scientific Thinking

Dimension 1: Science and Engineering Practices

1. Asking questions (science) and defining problems (engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (science) and designing solutions (engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

For each, the Framework includes a description of the practice, the culminating 12th grade learning goals, and what we know about progression over time.

NGSS: Dimension 1 – Scientific and Engineering Practices

Asking Questions and Defining Problems	
Science begins with a question about a phenomenon, such as “Why is the sky blue?” or “What causes cancer?” and seeks to develop theories that can provide explanatory answers to such questions. A basic practice of the scientist is formulating empirically answerable questions about phenomena, establishing what is already known, and determining	**Engineering** begins with a problem, need or desire that suggests an engineering problem that needs to be solved. A societal problem such as reducing the nation’s dependence on fossil fuels may engender a variety of engineering problems ,such as designing more efficient transportation systems, or alternative power generation devices such as improved solar

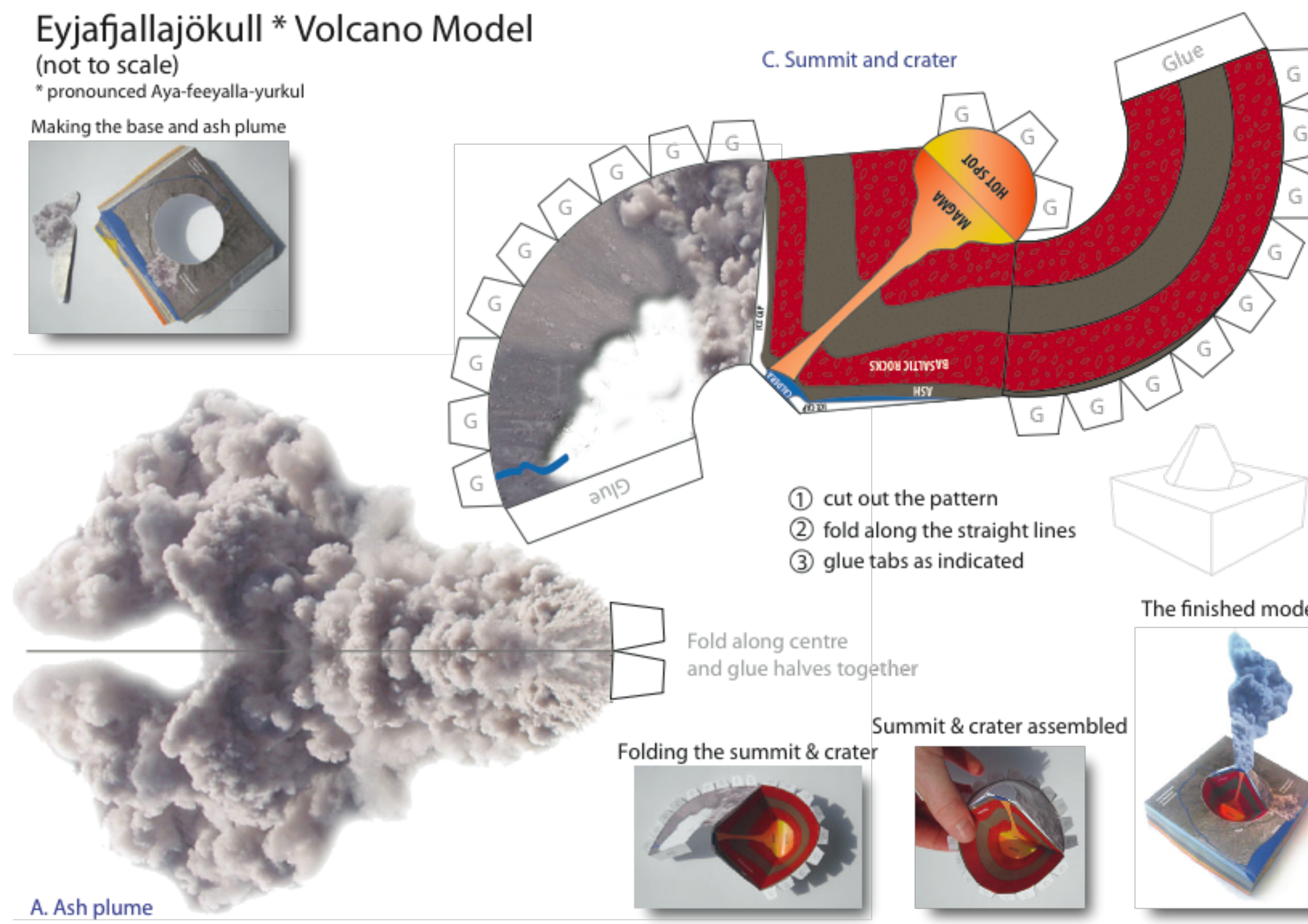
1. Asking Questions and Defining Problems - Questions engage!

- How do the gears on my bike work?
- What is the smallest piece of matter?
- Can I see in a room if it is truly dark?

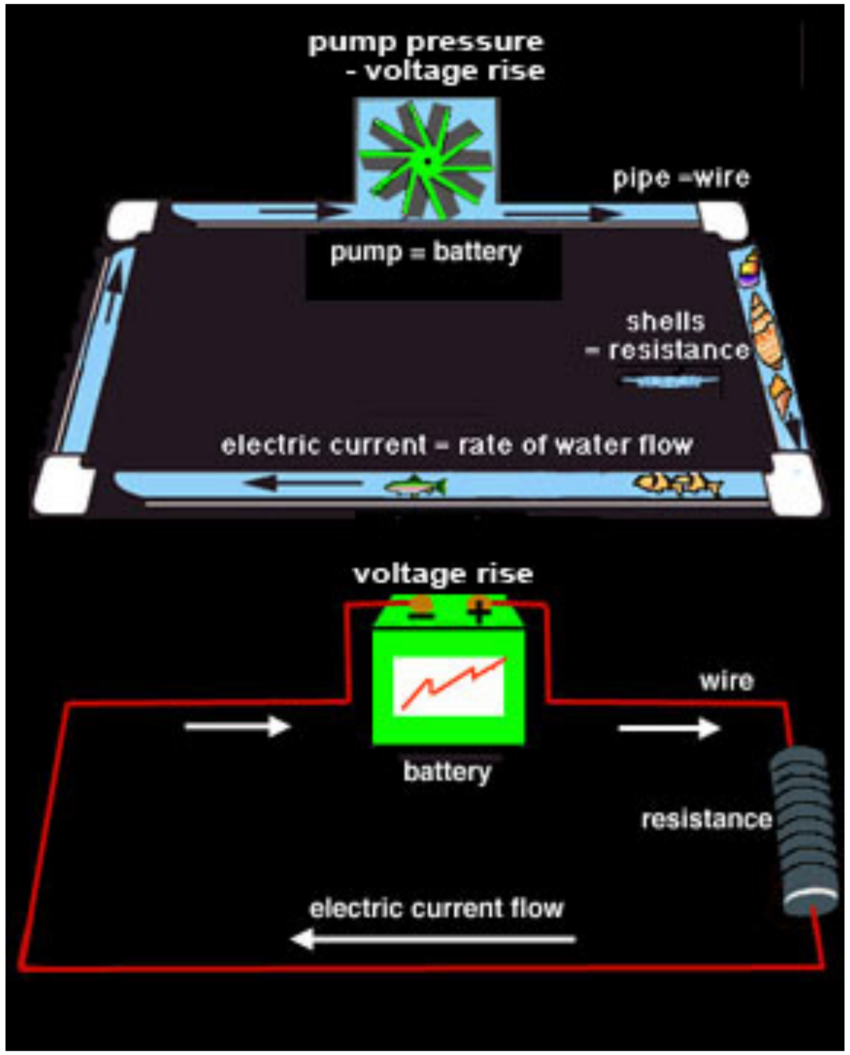
What Question is answered?

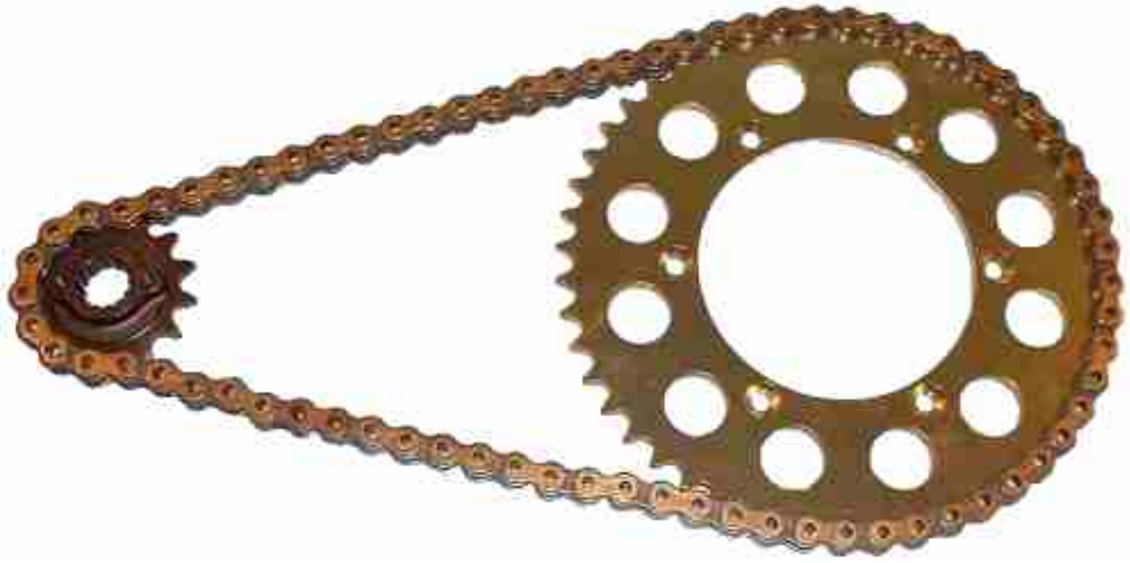
- Students know evaporation and melting are changes that occur when the objects are heated. (Grade 3)
- Students know evidence of plate tectonics is derived from the fit of the continents; the location of earthquakes, volcanoes, and mid-ocean ridges; and the distribution of fossils, rock types, and ancient climatic zones. (Grade 6)
- Students know that when one object exerts a force on a second object, the second object always exerts a force of equal magnitude and in the opposite direction (Newton's third law). (grade 9-12)
- Students know atoms combine to form molecules by sharing electrons to form covalent or metallic bonds or by exchanging electrons to form ionic bonds. (grade 9-12)

2. Developing and Using Models

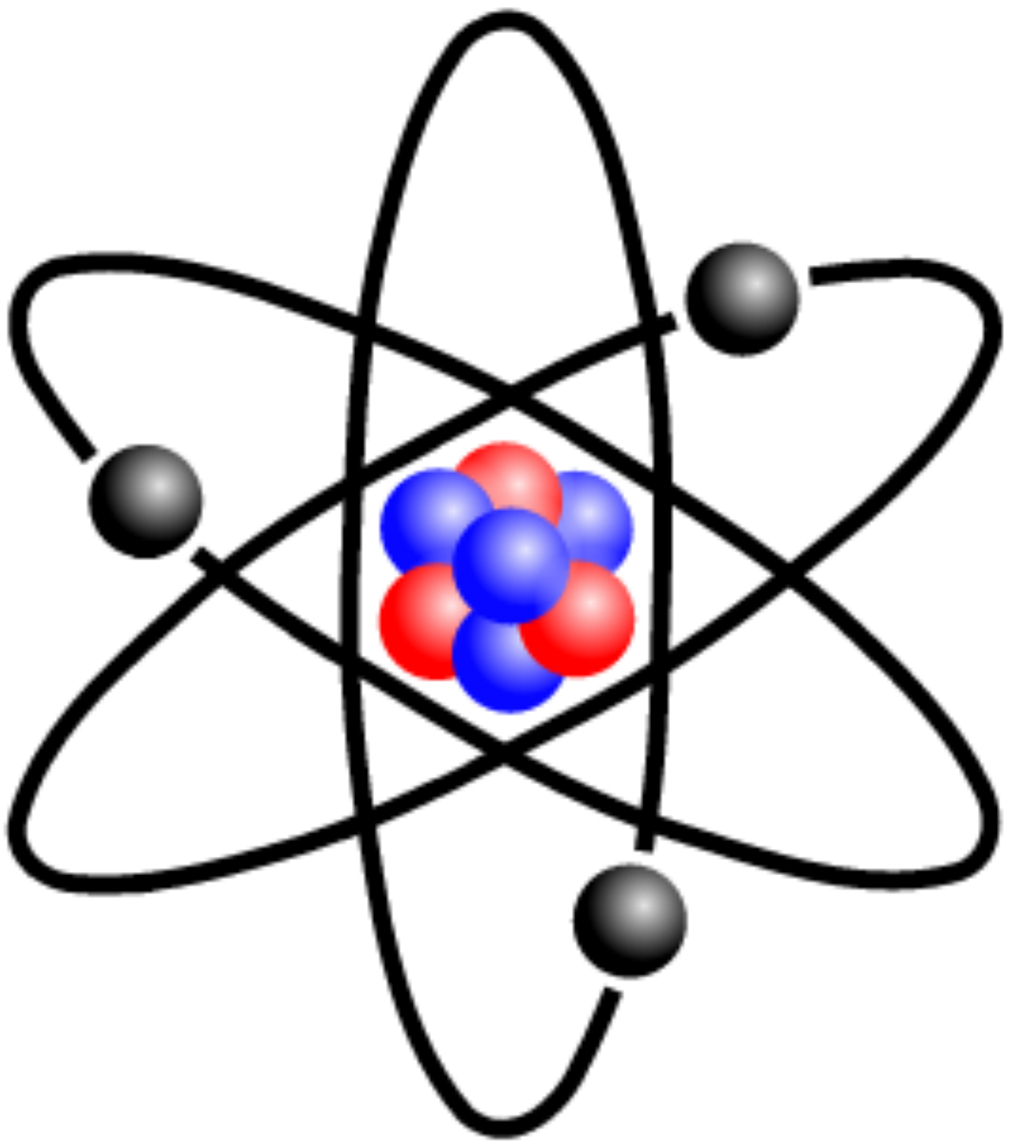


Water and Bicycle Models of an Electric Circuit





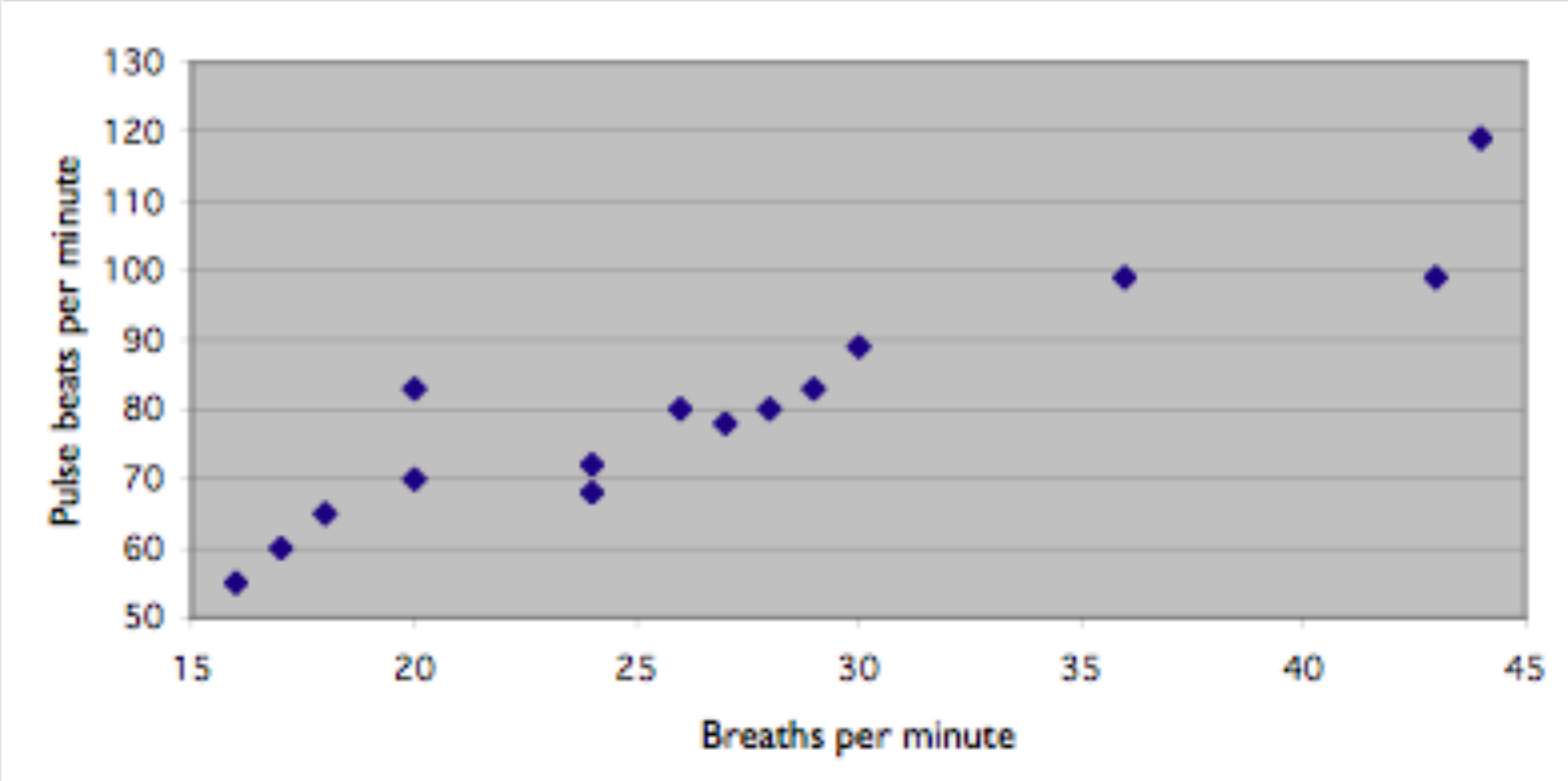
Bohr Model of the Atom



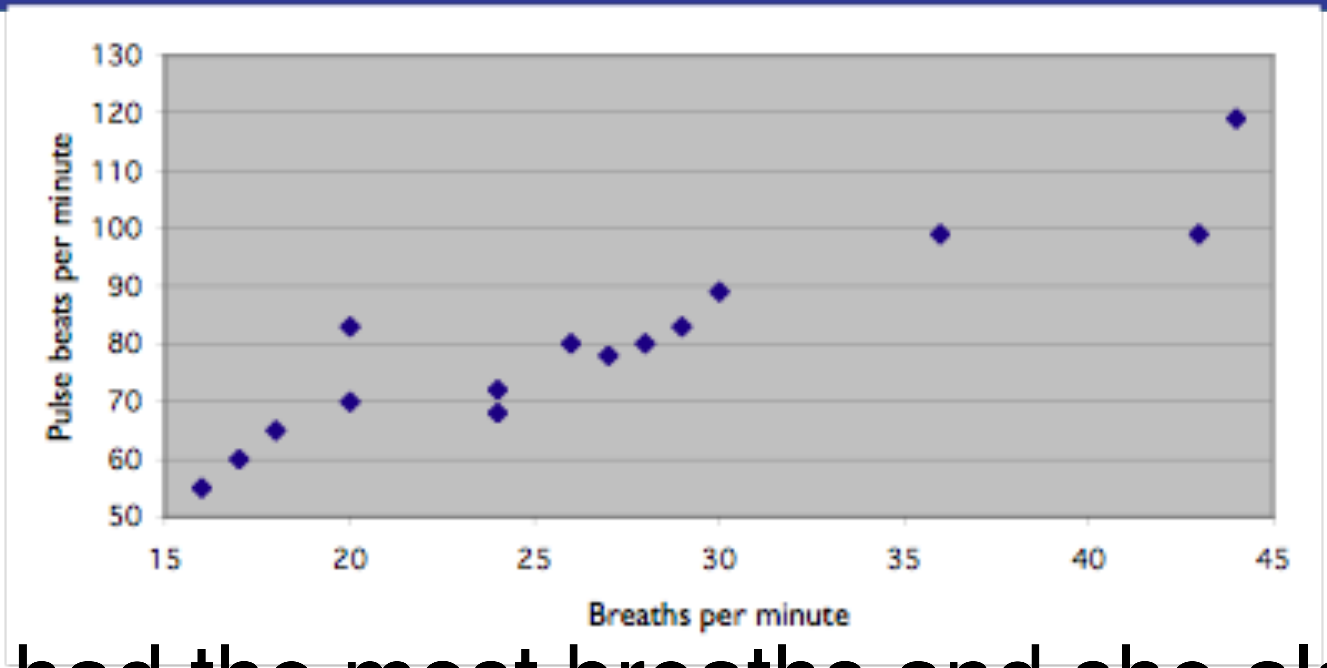
3. Planning and Carrying Out Investigations

How does the speed at which sugar dissolves depend on temperature?

4. Analyzing and Interpreting Data



4. Analyzing and Interpreting Data



(a) One pupil had the most breaths and she also had the highest pulse rate.

(b) All the people with a high breath rate had a high pulse rate.

(c) The higher your breathing rate, the greater the pulse rate.

(d) On the whole, those people with a higher breath rate had a higher pulse rate.

5. Using Mathematics and Computational Thinking

$$\nabla \times \mathbf{B} = \mu_0 \epsilon_0 \frac{\partial \mathbf{E}}{\partial t}$$

1. Who is the tallest
2. Who is the smallest
3. What is the average?

6. Constructing Explanations
The upside down tumbler

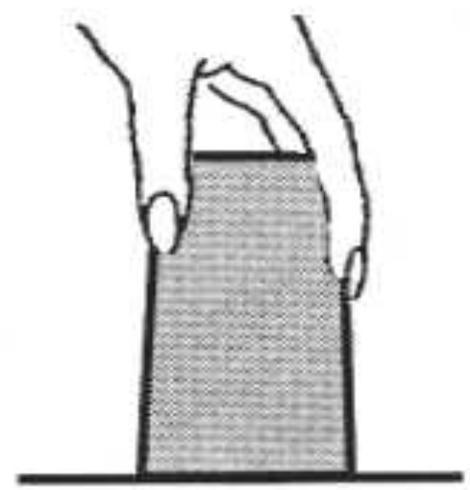
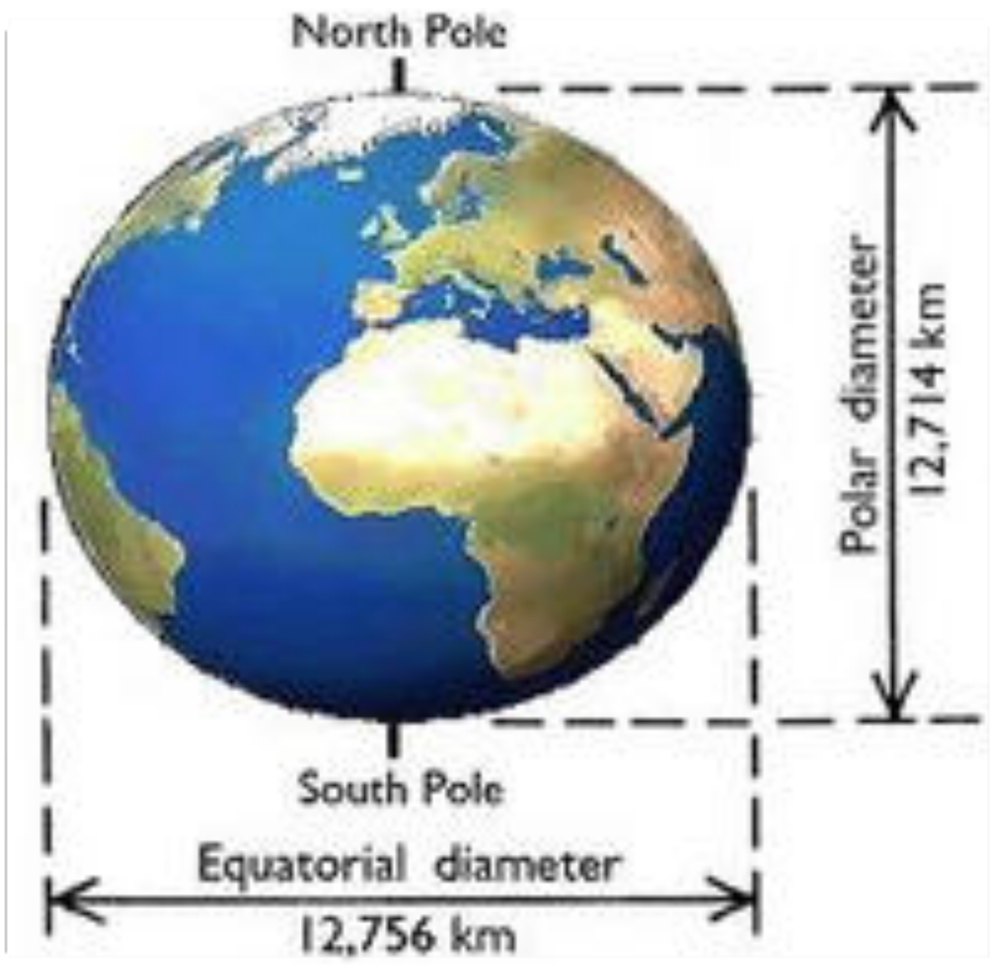


Fig. 2.

- There is no air inside
- There is no glue on the card
- There is lots of air outside
- Some of the air is hitting the card
- A force is needed to support the water

6. Constructing Explanations
The Shape of the Earth.



1. The Earth spins once a day
2. Rocks can be squeezed.
3. Gravity pulls all matter towards towards the center of the Earth
4. A squashed sphere is called an oblate spheroid
5. If something is spinning a force is needed towards the center to keep it going round in a circle.

7. Engaging in Argument from Evidence
The Significance of Argument?

Construction
[Recall and Explanation]

vs

Critique
[Juxtaposition & Evaluation

Something in the Air?

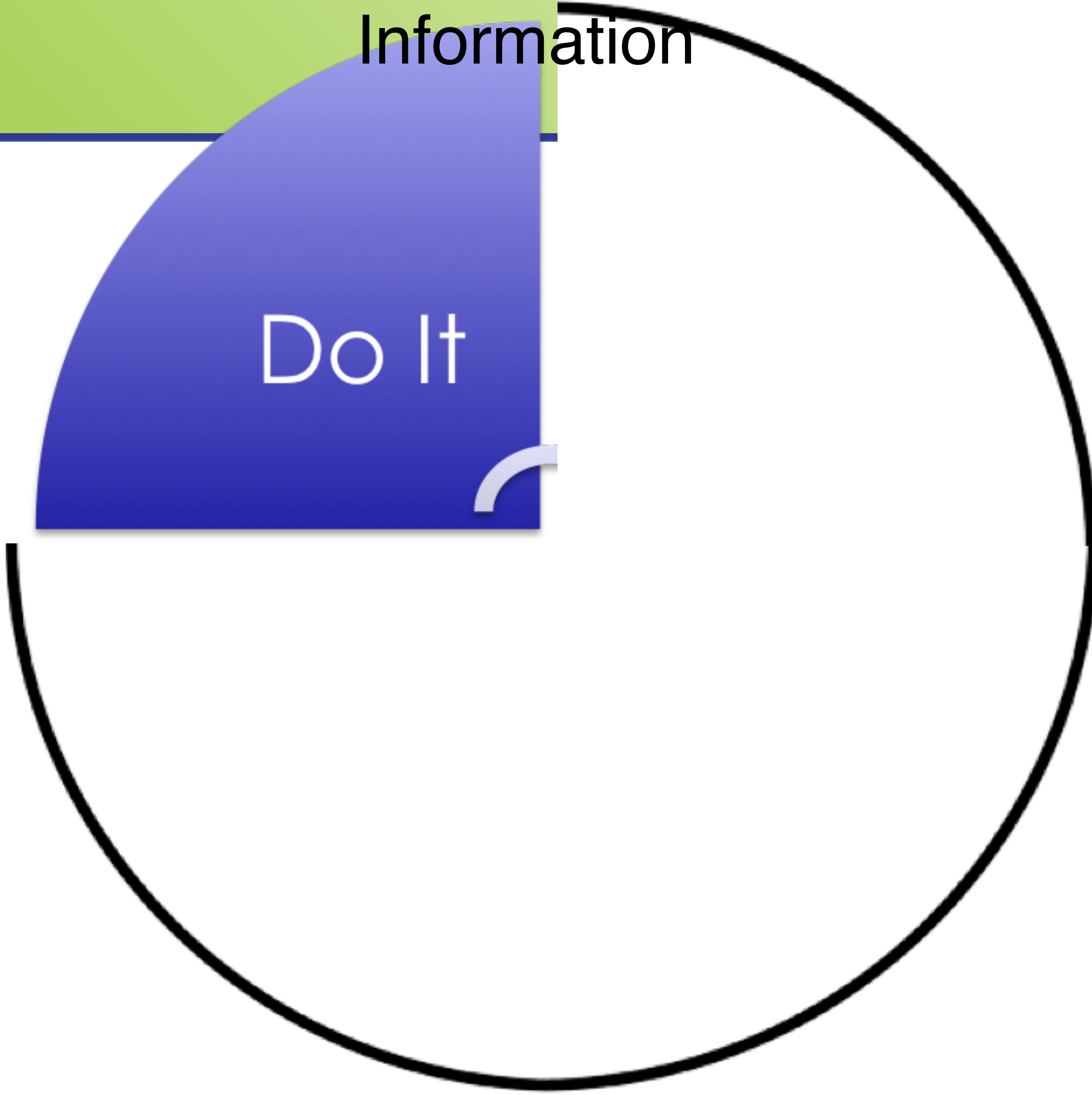
Maria, Ted and Alexis are wondering where the water on the outside of the glass of water with ice comes from.

Maria: The water came through holes in the glass.

Ted: The water came over the top of the glass.

Alexis: The water came from the air.

8. Obtaining, Evaluating and Communicating Information



Crosscutting Concepts

1. Patterns
2. Cause and effect
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter
6. Structure and function
7. Stability and change

Framework 4-1

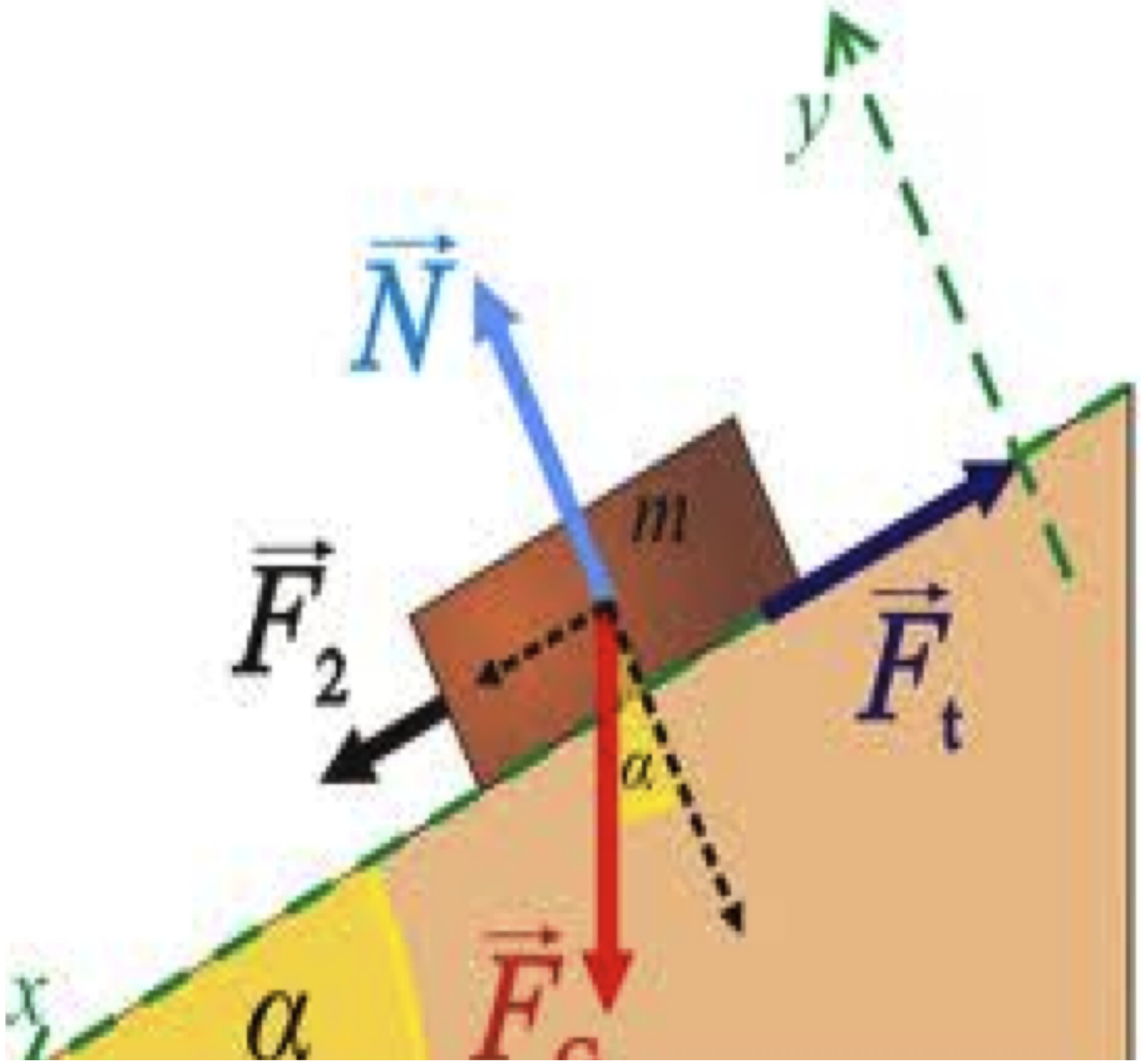
Disciplinary Core Ideas

A core idea for K-12 science instruction is a scientific idea that:

- Has broad importance across multiple science or engineering disciplines or is a key organizing concept of a single discipline
- Provides a key tool for understanding or investigating more complex ideas and solving problems
- Relates to the interests and life experiences of students or can be connected to societal or personal concerns that require scientific or technical knowledge
- Is teachable and learnable over multiple grades at increasing levels of depth and sophistication

Physical Sciences

- Matter and Its Interactions
- Motion and Stability
- Energy
- Waves and Their Applications

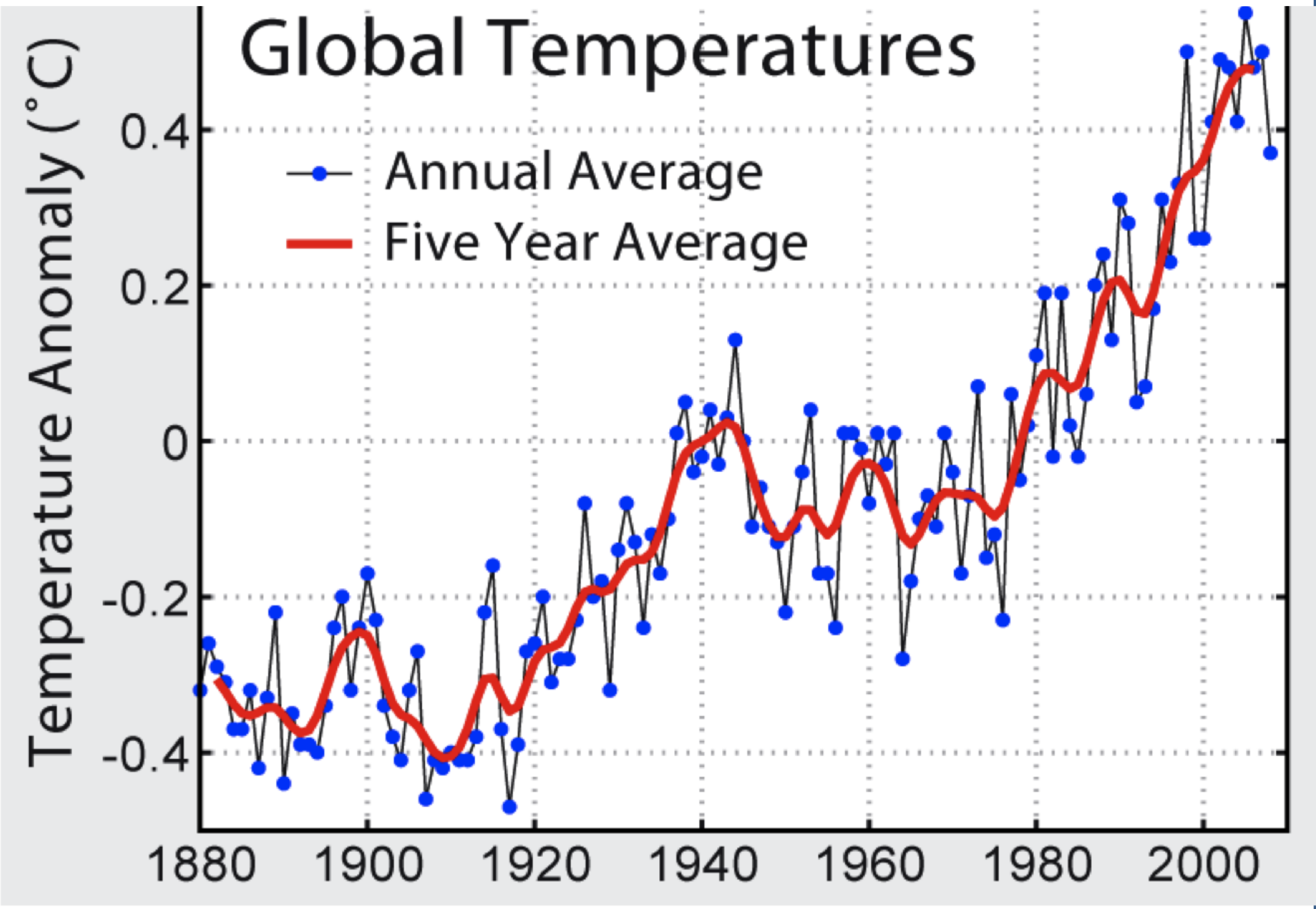


Life Sciences

- From Molecules to Organisms: Structures and Processes
- Ecosystems: Interactions, Energy, and Dynamics
- Heredity: Inheritance and Variation of Traits
- Biological Evolution: Unity and Diversity

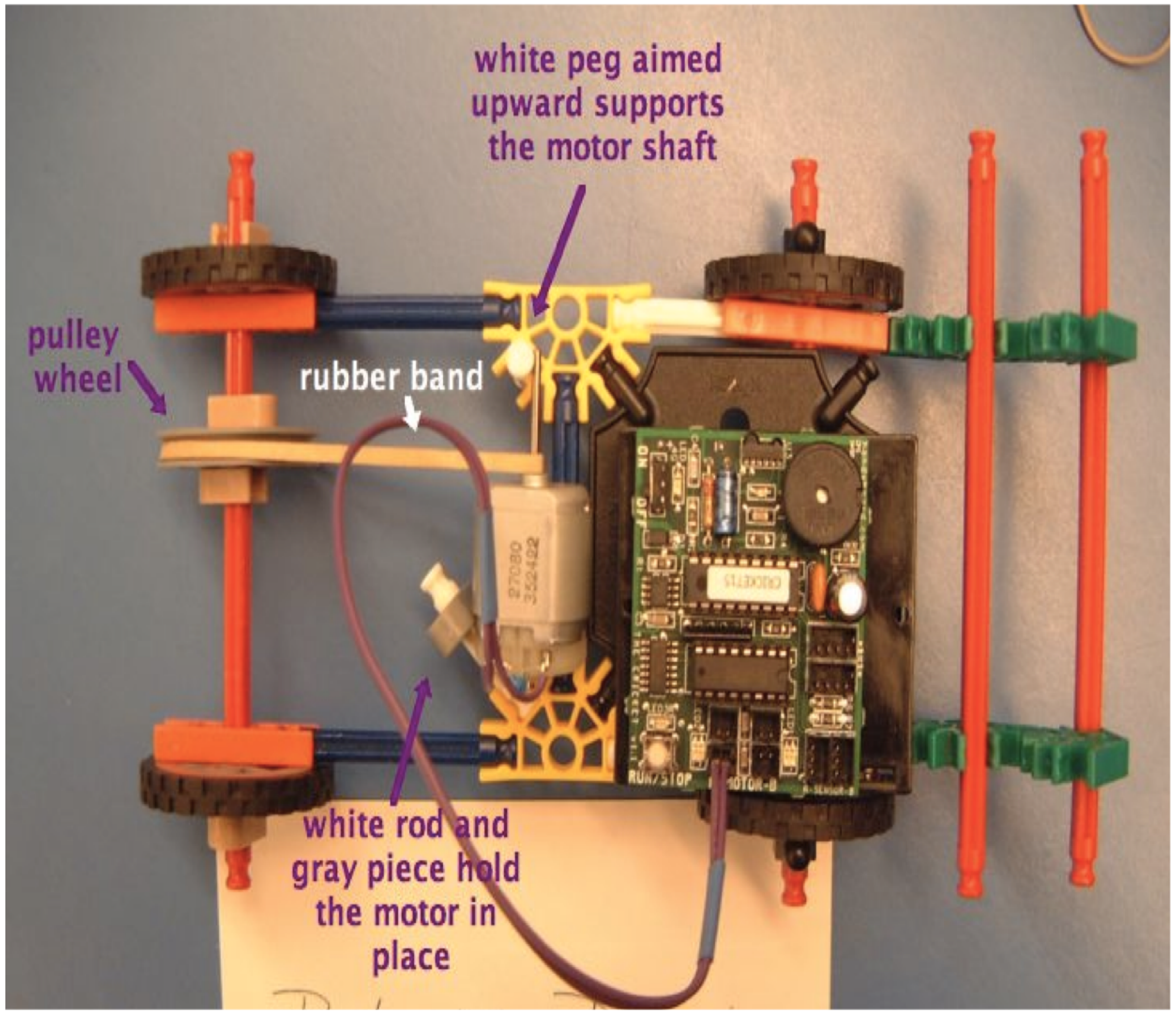
Earth and Space Sciences

- Earth's Place in the Universe
- Earth Systems
- Earth and Human Activity



Engineering, Technology and Applications of Sciences

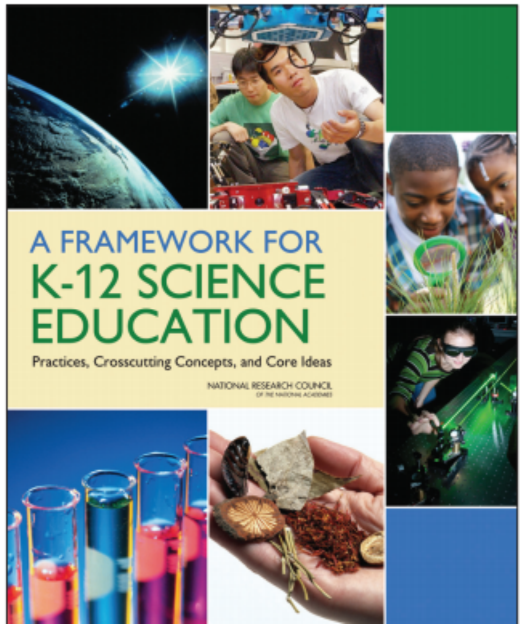
- Engineering Design
- Links Among Engineering, Technology, Science and Society



Principles of the Framework

- Children are born investigators
- Understanding builds over time
- Science and Engineering require both knowledge and practice
- Connecting to students' interests and experiences is essential
- Focusing on core ideas and practices
- Promoting equity

Lots of work completed, underway, and left to do



NEXT GENERATION SCIENCE STANDARDS

Assessments

Curricula

Instruction

Teacher Development

NGSS Development Timeline

- 2 - State and Organizational Reviews have taken place.
- 1 - Public Review has taken place.
- 2 - State and Organizational Reviews will take place this summer and fall.
- Next Public Review will take place in the fall.
- Final State and Organizational Review in the winter
- Completion of the Project in January or February

In-depth look at standards

- Formatting and coding
- Colors and codes of 3 dimensions
- Connection boxes within NGSS
- Connections between NGSS and CCSS in both literacy and math

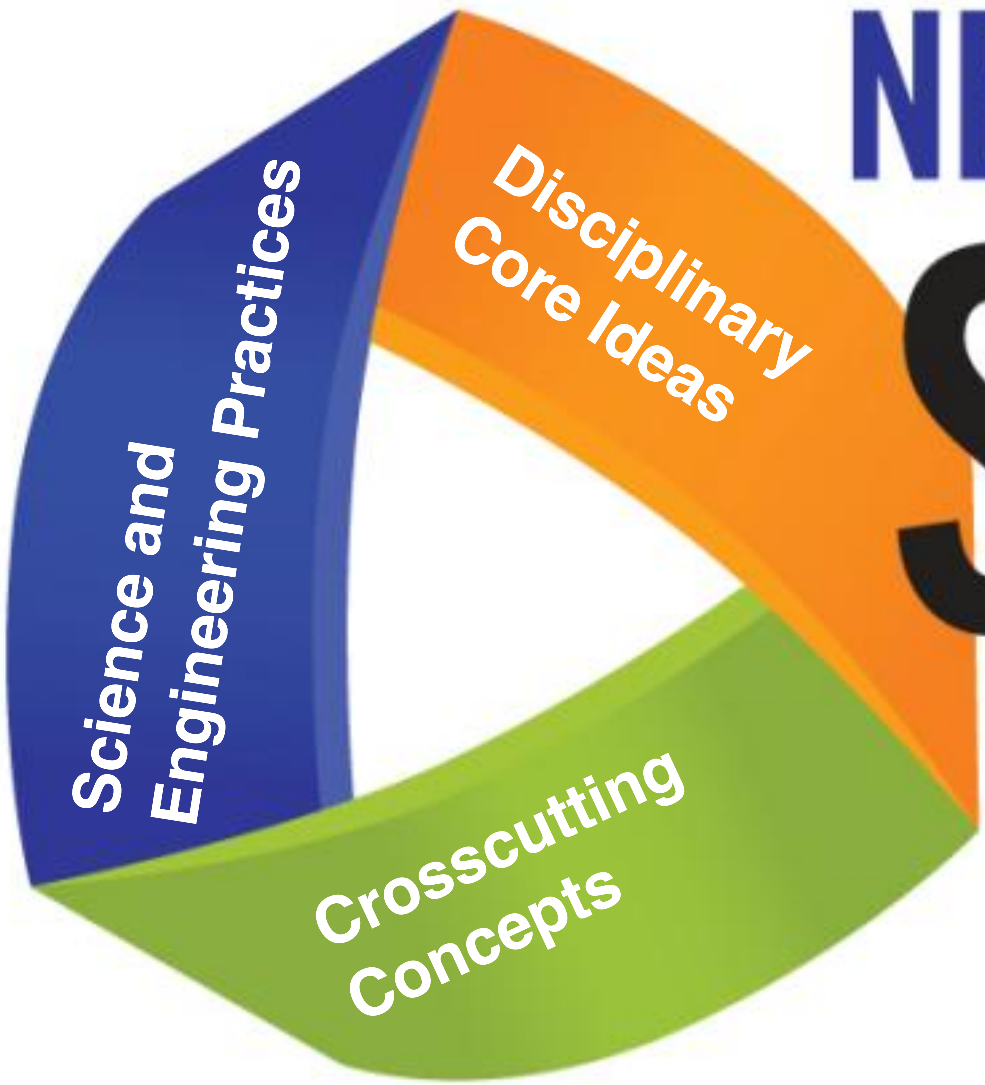
Connections to CCSS Literacy

- Determine Central Ideas (RST 2)
- Evidence (RST 1 & WHST9)
- Analysis (RST 5)
- Evaluate Hypotheses (RST 8)
- Synthesize Information (RST 9)
- Writing Arguments (WHST 1)
- Use of Technology (WHST 6)
- Speaking and Listening (SL 1-6)

Connections to CCSS Mathematics

Mathematical Practices

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.



NEXT GENERATION SCIENCE STANDARDS

Next Generation Science Standards…

Are:

- Performance Expectations focused on the nexus of the three dimensions of science learning
- Performance Expectations that require students demonstrate proficiency
- Designed to lead to a coherent understanding of the Practices, CCC, and DCIs

Are NOT:

- Separate sets of isolated inquiry and content standards
- Curriculum or instructional tasks, courses, experiences or materials
- Meant to limit the use of Practices or Crosscutting Concepts in instruction
- Designed to be separate or isolated experiences

Performance Expectations

MS.PS-SPM Structure and Properties of Matter

MS.PS-SPM Structure and Properties of Matter
Students who demonstrate understanding can: **a. Construct and use models to explain that atoms combine to form new substances of varying complexity in terms of the number of atoms and repeating subunits.** [Clarification Statement: Examples of atoms combining can include Hydrogen (H_2) and Oxygen (O_2) combining to form hydrogen peroxide (H_2O_2) or water (H_2O).] [Assessment Boundary: Valence electrons and bonding energy are not addressed.]

Performance Expectations

Foundation Boxes

MS.PS-SPM Structure and Properties of Matter

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The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to explain, explore, and predict more abstract phenomena and design systems. • Use and/or construct models to predict, explain, and/or collect data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs. (a)	**PS1.A: Structure and Properties of Matter** • All substances are made from some 100 different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (a) • Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). (a)	**Patterns** Macroscopic patterns are related to the nature of microscopic and atomic-level structure. Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems. Patterns can be used to identify cause and effect relationships. Graphs and charts can be used to identify patterns in data. (a)

Language was based on Framework and expanded into Matrices

NRC Framework language from Grade Band Endpoints

Language was based on Framework and expanded into Matrices

Performance Expectations

Foundation Boxes

Connection Boxes

MS.PS-SPM Structure and Properties of Matter

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Connections to other DCIs in this grade-level: **MS.ESS-ESP, MS.ESS-SS, MS.LS-MEOE**

Articulation of DCIs across grade-levels: **3.IF, 5.SPM, HS.PS.SPM, HS.PS-NP, HS.PS-E**

Common Core State Standards Connections: [Note: these connections will be made more explicit and complete in future draft releases]

ELA –

W.5.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

W.6.1 Write arguments to support claims with clear reasons and relevant evidence.

W.7.1 Write arguments to support claims with clear reasons and relevant evidence.

SL.5.4 Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.

SL.6.4 Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes; use appropriate eye contact, adequate volume, and clear pronunciation.

SL.7.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with pertinent descriptions, facts, details, and examples; use appropriate eye contact, adequate volume, and clear pronunciation.

WHST.6-8.1 Write arguments focused on discipline-specific content.

RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Mathematics –

MP.4 Model with mathematics.

MP.8 Look for and express regularity in repeated reasoning.

6.SP Develop understanding of statistical variability

Summarize and describe distributions

Progression Through the Grades

Scientific and Engineering Practices

Crosscutting Concepts

Connections between Technology, Engineering and the Application of Science

Science and Engineering Practices Matrix

Science Engineering Practices	K–2 Condensed Practices	3–5 Condensed Practices	6–8 Condensed Practices	9–12 Condensed Practices
Constructing Explanations and Designing Solutions *The products of science are explanations and the products of engineering are solutions.* The goal of science is the construction of theories that provide explanatory accounts of the world. A theory becomes accepted when it has multiple lines of empirical evidence and greater explanatory power of phenomena than previous theories. The goal of engineering design is a systematic solution to problems that is based on scientific knowledge and models of the material world. Each proposed solution results from a process of balancing competing criteria of desired functions, technical feasibility, cost, safety, aesthetics, and compliance with legal requirements. The optimal choice depends on how well the proposed solutions meet criteria and constraints.	Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence in constructing explanations and designing solutions. • Use information from observations to construct explanations about investigations. • Use tools and materials provided to design a solution to a specific problem.	Constructing explanations and designing solutions in 3–5 builds on prior experiences in K–2 and progresses to the use of evidence in constructing multiple explanations and designing multiple solutions. • Use quantitative relationships to construct explanations for observed events. • Use evidence (e.g., measurements, observations, patterns) to construct a scientific explanation or solution to a problem. • Distinguish evidence-based explanations from non-evidence based explanations. • Apply scientific knowledge to solve design problems.	Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories. • Use qualitative and quantitative relationships between variables to construct explanations for phenomena. • Apply scientific reasoning to link evidence to claims and show why the data is adequate for the explanation or conclusion. • Generate and revise causal explanations from data (e.g., observations, sources of reliable information) and relate these explanations to current knowledge. • Base explanations on evidence and the assumption that natural laws operate today as they did in the past and will continue to do so in the future. • Undertake design projects, engaging in the design cycle, to construct and implement a solution that meets specific design criteria and constraints. • Apply scientific knowledge to explain real-world examples or events and solve design problems. • Construct explanation from models or representations.	Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent sources of evidence consistent with scientific knowledge, principles, and theories. • Make quantitative claims regarding the relationship between dependent and independent variables. • Apply scientific reasoning, theory, and models to link evidence to claims and show why the data is adequate for the explanation or conclusion. • Construct and revise explanations and arguments based on evidence obtained from a variety of sources (e.g., scientific principles, models, theories) and peer review. • Base casual explanations on valid and reliable empirical evidence from multiple sources and the assumption that natural laws operate today as they did in the past and will continue to do so in the future. • Apply scientific knowledge to solve design problems by taking into account possible unanticipated effects.

Crosscutting Concepts Matrix

2. *Cause and Effect: Mechanism and Prediction* – Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.			
K-2 Crosscutting Statements	**3-5 Crosscutting Statements**	**6-8 Crosscutting Statements**	**9-12 Crosscutting Statements**
Events have causes that generate observable patterns. Simple tests can be designed to gather evidence to support or refute student ideas about causes.	Cause and effect relationships are routinely identified, tested, and used to explain change. Events that occur together with regularity might or might not be a cause and effect relationship.	Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. Cause and effect relationships may be used to predict phenomena in natural or designed systems. Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.	Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. Systems can be designed to cause a desired effect. Changes in systems may have various causes that may not have equal effects.

3. *Scale, Proportion, and Quantity* – In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.			
K-2 Crosscutting Statements	**3-5 Crosscutting Statements**	**6-8 Crosscutting Statements**	**9-12 Crosscutting Statements**
Relative scales allow objects to be compared and described (e.g. bigger and smaller; hotter and colder; faster and slower). Standard units are used to measure length.	Natural objects and observable phenomena exist from the very small to the immensely large. Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.	Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. The observed function of natural and designed systems may change with scale. Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. Scientific relationships can be represented through the use of algebraic expressions and equations.	The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. Patterns observable at one scale may not be observable or exist at other scales. Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g. linear growth vs. exponential growth).

Connections to Engineering, Technology, and Applications of Science Matrix

1. Interdependence of Science, Engineering, and Technology – The fields of science and engineering are mutually supportive. Advances in science offer new capabilities, new materials, or new understandings that can be applied through engineering to produce advances in technology. Advances in technology by engineers, in turn, provide scientists with new capabilities to probe the natural world.			
K-2 Crosscutting Statements	**3-5 Crosscutting Statements**	**6-8 Crosscutting Statements**	**9-12 Crosscutting Statements**
Science and engineering involve the use of tools to observe and measure things.	Science and technology support each other. Tools and instruments are used to answer scientific questions, while scientific discoveries lead to the development of new technologies.	Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems. Science and technology drive each other forward.	Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.

2. Influence of Engineering, Technology, and Science on Society and the Natural World – Advances in science and engineering have influenced the ways in which people interact with one another and with their surrounding natural and designed environments. Society's decisions about technology (whether made through market forces or political processes) influence the work of scientists and engineers.			
K-2 Crosscutting Statements	**3-5 Crosscutting Statements**	**6-8 Crosscutting Statements**	**9-12 Crosscutting Statements**
Every human-made product is designed by applying some knowledge of the natural world and is built by using natural materials. Taking natural materials to make things impacts the environment.	People's needs and wants change over time, as do their demands for new and improved technologies. Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. When new technologies become available, they can bring about changes in the way people live and interact with one another.	All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. The uses of technologies are driven by people's needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Technology use varies over time and from region to region.	Modern civilization depends on major technological systems, such as agriculture, health, water, energy, transportation, manufacturing, construction, and communications. Engineers continuously modify these systems to increase benefits while decreasing costs and risks. New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Conceptual Shifts in the NGSS

1. K–12 science education should reflect the real world interconnections in science
2. Science and Engineering Practices and Crosscutting Concepts should not be taught in a vacuum; they should always be integrated with multiple core concepts throughout the year
3. Science concepts build coherently across K-12
4. The NGSS focus on deeper understanding and application of content
5. Integration of science and engineering
6. Coordination with Common Core State Standards

Standards Comparison: Structure and Properties of Matter

Current State Middle School Science Standard

a. Distinguish between atoms and molecules.
b. Describe the difference between pure substances (elements and compounds) and mixtures.
c. Describe the movement of particles in solids, liquids, gases, and plasmas states.
d. Distinguish between physical and chemical properties of matter as physical (i.e., density, melting point, boiling point) or chemical (i.e., reactivity, combustibility).
e. Distinguish between changes in matter as physical (i.e., physical change) or chemical (development of a gas, formation of precipitate, and change in color).
f. Recognize that there are more than 100 elements and some have similar properties as shown on the Periodic Table of Elements.
g. Identify and demonstrate the Law of Conservation of Matter.

NGSS Middle School Sample

a. Construct and use models to explain that atoms combine to form new substances of varying complexity in terms of the number of atoms and repeating subunits.
b. Plan investigations to generate evidence supporting the claim that one pure substance can be distinguished from another based on characteristic properties.
c. Use a simulation or mechanical model to determine the effect on the temperature and motion of atoms and molecules of different substances when thermal energy is added to or removed from the substance.
d. Construct an argument that explains the effect of adding or removing thermal energy to a pure substance in different phases and during a phase change in terms of atomic and molecular motion.

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Organization of the NGSS

Organized by Disciplinary Content
- Physical Science
- Life Science
- Earth-Space Science
- Engineering

K-5
- Grade By Grade
- Engineering concepts are integrated into performance expectations

6-8
- Grade Banded
- Model Pathways to follow the second public draft

9-12
- Grade Banded
- Model Pathways to follow the second public draft

HS.LS-MEOE Matter and Energy in Organisms and Ecosystems

How to read the standards »

Go to the NGSS Survey

Views: Black and white / Practices and Core Ideas / Practices and Crosscutting Concepts / PDF

Students who demonstrate understanding can:

a. **Construct a model to support explanations of the process of photosynthesis by which light energy is converted to stored chemical energy.** [Clarification Statement: Models may include diagrams and chemical equations. The focus should be on the flow of matter and energy through plants.] [*Assessment Boundary: Limited to the inputs and outputs of photosynthesis and chemosynthesis, not the specific biochemical steps involved.*]

b. **Construct an explanation of how sugar molecules that contain carbon, hydrogen, and oxygen are combined with other elements to form amino acids and other large carbon-based molecules.** [Clarification Statement: Explanations should include descriptions of how the cycling of these elements provide evidence of matter conservation.] [*Assessment Boundary: Focus is on conceptual understanding of the cycling of matter and the basic building blocks of organic compounds, not the actual process.*]

c. **Use a model to explain cellular respiration as a chemical process whereby the bonds of food molecules and oxygen molecules are broken and bonds in new compounds are formed that result in a net transfer of energy.** [*Assessment Boundary: Limited to the conceptual understanding of the inputs and outputs of metabolism, not the specific steps.*]

d. **Evaluate data to compare the energy efficiency of aerobic and anaerobic respiration within organisms.** [*Assessment Boundary: Limited to a comparison of ATP input and output.*]

e. **Use data to develop mathematical models to describe the flow of matter and energy between organisms and the ecosystem.** [*Assessment Boundary: Use data on energy stored in biomass that is transferred from one trophic level to another.*]

f. **Communicate descriptions of the roles of photosynthesis and cellular respiration in the carbon cycle specific to the carbon exchanges among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.**

g. **Provide evidence to support explanations of how elements and energy are conserved as they cycle through ecosystems and how organisms compete for matter and energy** [Clarification Statement: Elements included can include carbon, oxygen, hydrogen, and nitrogen.]

NEXT GENERATION SCIENCE STANDARDS

IMPLEMENTATION

Developing and Using Models

Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and constructing models to predict and explain relationships between systems and their components in the natural and designed world.

- Use multiple types of models to represent and explain phenomena and move flexibly between model types based on merits and limitations.
- Construct, revise, and use models to predict and explain relationships between systems and their components.
- Examine merits and limitations of various models in order to select or revise a model that best fits the evidence or the design criteria.

and Ecosystems

Go to the NGSS Survey

ck and white / Practices and Core Ideas / Practices and Crosscutting Concepts / PDF

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g. Provide evidence to support explanations of how elements and energy are conserved as they cycle through ecosystems and how organisms compete for matter and energy **[Clarification Statement: Elements included can include carbon, oxygen, hydrogen, and nitrogen.]**

HS.LS-MEOE Matter and Ener

LS1.C: Organization for Matter and Energy Flow in Organisms

- The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells.

How to read the standards »

Go to the NGSS Survey

ractices and Crosscutting Concepts / PDF

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Energy and Matter

The total amount of energy and matter in closed systems is conserved. Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. Energy drives the cycling of matter within and between systems. In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

HS.LS-MEOE Matter and Ener

How to read the standards »

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The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models
Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and constructing models to predict and explain relationships between systems and their components in the natural and designed world.

- Construct, revise, and use models to predict and explain relationships between systems and their components. (b)

Planning and Carrying Out Investigations
Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that build, test, and revise conceptual, mathematical, physical and empirical models.

- Plan and carry out investigations individually and collaboratively and test designs as part of building and revising models, explaining phenomena, or testing solutions to problems. Consider possible confounding variables or effects, and ensure that the investigation's design has controlled for them. (c)

Using Mathematics and Computational Thinking
Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

- Use mathematical expressions to represent phenomena or design solutions in order to solve algebraically for desired quantities. (a)

Obtaining, Evaluating, and Communicating Information
Obtaining, evaluating, and communicating information in 9–12 builds on 6–8 and progresses to evaluate the validity and reliability of the claims, methods, and designs.

- Generate, synthesize, communicate, and critique claims, methods and designs that appear in scientific and technical texts or media reports. (d), (e)

Disciplinary Core Ideas

PS2.B: Types of Interactions

- Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (a)
- Forces at a distance are explained by fields permeating space that can transfer energy through space. Magnets or changing electric fields cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (c)
- Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (b),(e)
- The strong and weak nuclear interactions are important inside atomic nuclei—for example, they determine the patterns of which nuclear isotopes are stable and what kind of decays occur for unstable ones. (d)

Crosscutting Concepts

Cause and Effect
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. Systems can be designed to cause a desired effect. Changes in systems may have various causes that may not have equal effects. (a),(b),(c),(d)

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Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology
Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (e)

Connections to other DCIs in this grade-level: **HS.ETS-ETSS, HS.ESS-SS, HS.ESS-ES**

Articulation of DCIs across grade-levels: **MS.PS-IF, MS.PS-FM**

Common Core State Standards Connections: [Note: these connections will be made more explicit and complete in future draft releases]

ELA

RST.9-10.7	Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
RST,11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
WHST.9	Draw evidence from informational texts to support analysis, reflection, and research.

Public Reaction

NGSS Draws Friendly Fire

Implications for GLOBE

Dimension 1 -- Practices

GLOBE??

Dimension 2 -- Crosscutting Concepts

GLOBE??

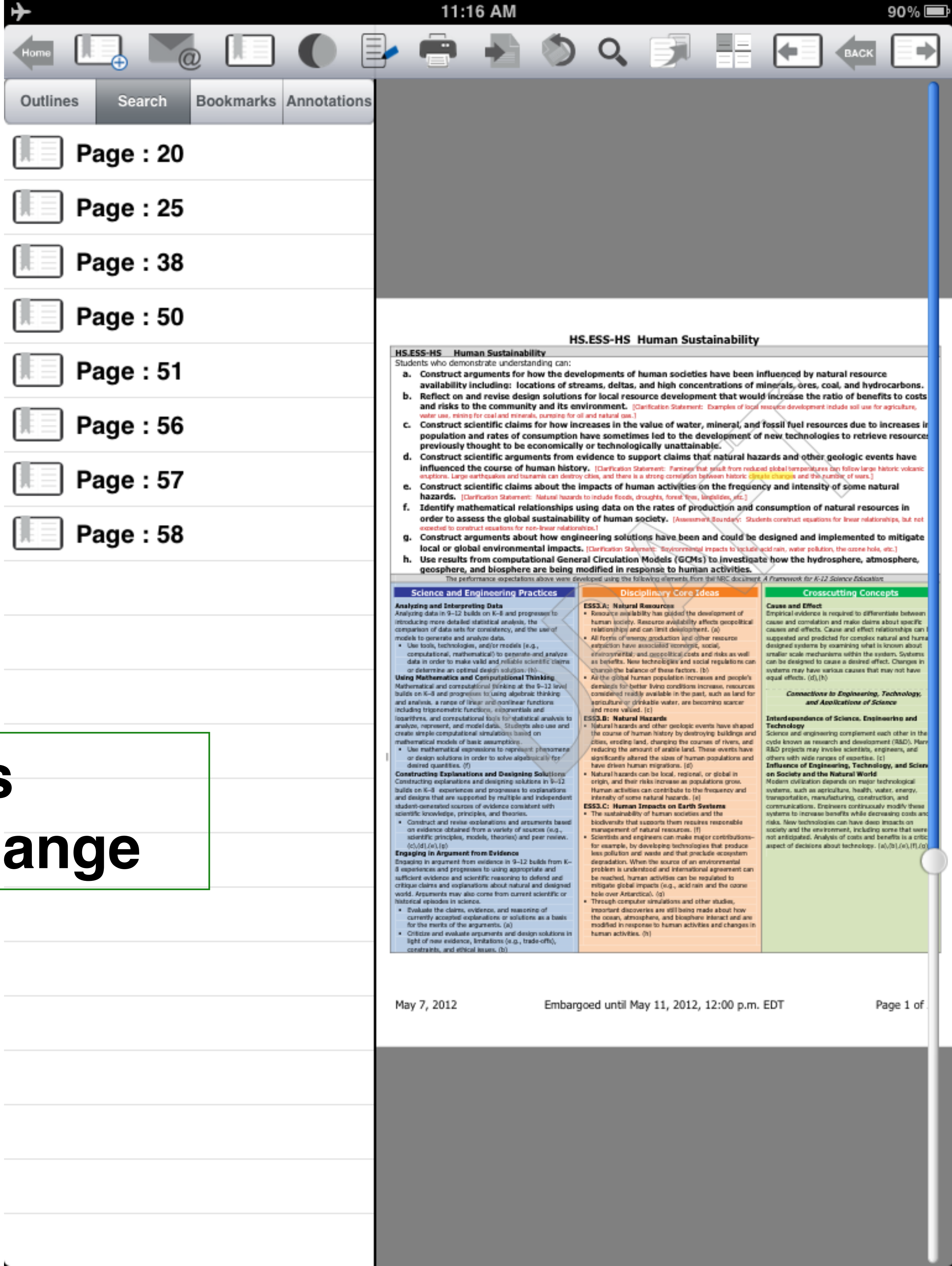
Dimension 3 -- Discipline Core Ideas

GLOBE??

Technology, Engineering, and the Application of Science

GLOBE??

Model Project for Professional Development



Specific standards focusing on climate change

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